DOCUMENT RESUME

ED 255 377 SE 045 471

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TITLE Assessment of Mathematics Remediation at Ramapo College of New Jersey.
PUB DATE Apr 85
NOTE 24p.; Paper presented at the Annual Meeting of the American Educational Research Association (69th, Chicago, IL, March 31-April 4, 1985).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Algebra; *College Mathematics; *Computation; Curriculum Development; Educational Research; Evaluation; Higher Education; Mathematics Curriculum; *Mathematics Instruction; *Remedial Instruction; *Remedial Mathematics
IDENTIFIERS *Mathematics Education Research

ABSTRACT

This study assessed the effectiveness of the remedial/developmental mathematics program developed at Ramapo College of New Jersey. Data was gathered from a random sample of 604 students who participated in the program for at least part of the three-year period 1981-84 and for whom both pretest and posttest scores were available in at least one skill area (computation or algebra). The New Jersey College Basic Skills Placement Test was used, with 30 computation items and 30 algebra items. Significant differences were found between pre- and posttest scores over the three-year period, for both computation and algebra. Over 72 percent of the students enrolled in the remedial/developmental courses successfully completed them. Furthermore, the findings indicated that the program contributed significantly to the improvement of students' mathematics skills and that they retained a great deal of the content learned. Students successfully completing the program appeared to have the same opportunity for success in subsequent mathematics courses as did students not requiring remediation. (MNS)

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Assessment of Mathematics Remediation at Ramapo College of New Jersey

by

Gabriella Wepner

April 1985

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ASSESSMENT OF MATHEMATICS REMEDIATION AT RAMAPO COLLEGE OF NEW JERSEY

The purpose of this study was to assess the effectiveness of the remedial/developmental mathematics program developed at Ramapo College of New Jersey, a four year state college and to show that mathematics remediation can be highly successful as evidenced by an expost facto evaluation of the program.

Perspective

For years, colleges throughout the country have been struggling with various degrees of success to address the inadequacy of mathematical skills brought to postsecondary institutions by entering freshmen and returning adult students. Although almost every college and university in the nation offers some type of remediation in mathematics, assessments of these remedial efforts have been relatively imprecise. Generally, there have been vague descriptions of program evaluation procedures and the results quoted have been in terms of the number or percentage of students successfully completing the remedial process.

The primary aim of postsecondary mathematics remediation is to sufficiently improve the mathematical skills of remedial students so they can successfully complete college level mathematics or mathematics dependent courses. The expectation is that successful remediation will allow the same opportunity of success to remedial students as is available to students

not requiring remediation.

Given the huge number of students demonstrating mathematical skill deficiencies, successful mathematics remediation becomes crucial for the maintenance of a viable pool of students who can choose the more technically or mathematically oriented fields needed in our society.

Unfortunately, despite the proliferation of large scale remedial mathematics programs and their concimmitant high costs both to institutions and to the students involved, there has been little concrete evidence to affirm that mathematics remediation on the college level is actually successful in achieving its purpose. In order to provide such evidence, program evaluations must address questions such as:

1. How much of an improvement is demonstrated by students in the program?

2. Are program results consistent over time?

3. Was the instruction provided responsible for student progress or did maturation or other work in college lead to improved student mathematical skill performance.

4. Do students remember what they learned in the program?

5. How well do remedial/developmental students fare in comparison to non-remedial/developmental students in other mathematics courses?

Objectives

In order to provide answers to the previous questions, the specific objectives of the study were to determine the

following:

1. Do significant differences exist between the pre-instructional skills assessment of students in remedial/developmental mathematics courses and their post-instructional skills assessment?

2. Are these differences consistent, i.e. does the program achieve similar results each year?

3. Does the remedial/developmental mathematics instruction provided significiantly contribute to the improvement of student mathematical skills?

4. Do students who have participated in the program demonstrate retention of content over time?

5. Do students successfully completing the remedial and/or developmental courses demonstrate similar achievement when compared to non remedial/nondevelopmental students in the same subsequent mathematics courses.

Procedures

Data Source

To achieve the objectives of the study, data was gathered on a random sample of 604 remedial/developmental students who participated in the program during at least part of the three year period 1981-1984 and for whom both pretest and posttest scores were available in at least one skill area. The data collected consisted of placement scores, pretest scores and posttest scores in computation and algebra. The

instruments used for all testing were alternate forms of the New Jersey College Basic Skills Placement Test (NJCBSPT), Computation and/or Algebra sections.

The NJCBSPT is used to assess student basic skills competencies by the entire state college system and also by many independent New Jersey colleges and universities. The Computation section consists of 30 multiple choice questions dealing with fractions, decimals, percent and simple arithmetic type word problems. The content is limited to elementary school topics. The Algebra section also consists of 30 multiple choice questions dealing with elementary algebra. Content is comparable to topics covered in secondary school first-year algebra courses. The validity and reliability for this instrument has been established through the auspices of the Educational Testing Service (ETS), Princeton, New Jersey.

The New Jersey College Basic Skills Placement Test is administered to all entering Freshmen upon admission to college, usually during the summer months prior to the Fall semester. The results are used to determine appropriate placement of students into remedial, developmental or college-level courses. Not all students, however, enroll in the required courses immediately.

Placement criteria at Ramapo College are as follows:

1. Remedial Course (BCM) - computation score of less than 16 out of 30 correct.

The remedial course emphasizes computational skills and pre-algebra skills.

2. Development Course (ICM) - computation score between

16 and 21 correct out of 30, algebra score less than 15 out of 30 correct.

3. Developmental course (IM) - computation score greater than 21 out of 30 correct and algebra score less than 21 correct out of 30.

Both developmental courses emphasize elementary algebra skills.

4. College-level course (College Algebra) - algebra score greater than 21 out of 30 correct.

Placement score data for this study consisted of the results of the initial placement testing administered during the Spring and Summer of 1981, '82, '83, and '84.

The pretest data for the study consisted of scores achieved on a form of the NJCBSPT administered during the first week of classes to students enrolled in program courses (remedial and/or developmental classes) and in the College Algebra classes. This testing was also the data source for measuring retention of content learned, since a student successfully completing the remedial and/or developmental course who enrolled in the subsequent developmental course or College Algebra course was pretested in that course a semester or more later.

Posttest data consisted of scores achieved on an alternate form of the NJCBSPT administered during the last week of classes in each course, each semester. Remedial (BCM) students were posttested in computation only. Developmental (ICM or IM) students were posttested in Computation and Algebra.

The data source for evaluating success in college-level

mathematics courses consisted of final grades received in College Algebra classes in which at least five former remedial/developmental students were enrolled. Thus there were 130 non-remedial/developmental students and 75 former remedial/developmental students in this sample.

Methods

To achieve the objectives of the study an ex post facto analysis of data was conducted for a three year period 1981-1984. 604 remedial and/or developmental students who participated in the program for at least part of the three year period (1981-1984) were randomly selected. Pretest, posttest, and placement data were collected and analyzed according to the specifically stated objectives of the study.

1. In order to determine if significant differences existed between the pre-instructional skills assessment of students enrolled in remedial/developmental mathematics and their post-instructional skills assessment, pretest scores in computation were compared to posttest scores in computation for remedial students and pretest scores in computation and algebra were compared to respective posttest scores for developmental students.

2. To determine if the differences between pretest and posttest scores were consistent over time, these scores were compared by skill area, and course level, each semester, for each academic year 1981-1984.

3. As this was an ex post facto study it was impossible

to use an experimental design with experimental/control groups to show that the program's instructional activities were clearly responsible for the improved mathematical skills performance of the students in the program. Consequently an alternative evaluation design was implemented to determine if the remedial/developmental program activities significantly contributed to the improvement of student mathematical skills. Placement, pretest, and posttest data for students who initially enrolled in the college at the same time were analyzed.

From the initial group of 604 students, data for 164 students who first enrolled at the college in Fall 1983 was grouped according to those students who enrolled in remedial/developmental courses in Fall '83 (first semester) and those who waited until Spring '84 (second semester) to enroll in remedial/developmental courses. This population was chosen since the largest group in the random sample was from 1983-84 academic year. Comparisons were as follows:

a) Initial placement scores of students who enrolled in remedial or developmental courses in their first semester were compared to the initial placement scores of students who enrolled in remedial or developmental courses in their second semester. This comparison was conducted to ensure the comparability of the two groups on this measure for initial mathematical skill ability.

b) Pretest scores for students enrolled in their first semester were compared to the pretest scores of students enrolled in their second semester in the same course. The assumption here was that if factors such as maturation, exposure

to other college courses, test taking experience, etc., contributed to improved mathematical skill performance, then students taking the pretest in Spring '84 should score significantly higher than students who were pretested in Fall '83 given no significant differences in initial placement scores.

c) Posttest scores for students enrolled in their first semester were compared to posttest scores for students enrolled the second semester in the same course. The assumption here was that if factors other than program activities contributed significantly to improved mathematical skills performance then Spring '84 posttest scores should be significantly higher than Fall '83 posttest scores because of the extended exposure time to such factors available to second semester students.

d) Pretest scores and posttest scores were compared for those students who enrolled in the remedial or developmental course during their first semester. Pretest scores of students enrolled in their second semester were compared to posttest scores of students enrolled in the first semester. The assumption here was that if factors unrelated to the program's activities contributed significantly to the improvement of student mathematical skills then the differences between first semester posttest scores and second semester pretest scores should not be as significant as the difference between first semester pretest scores and first semester posttest scores.

4. To determine if students who participated in the program could demonstrate retention of content, initial pretest scores in computation and algebra were compared to respective

retention test scores achieved at least one semester later during subsequent course pretesting. Posttest scores achieved at the end of instruction in computation and algebra were compared to respective retention test scores achieved at least one semester later in subsequent course pretesting. Of the original 604 students in the sample there were 85 students for whom pretest, posttest and retention (pretest) data were available in computation and 115 students for whom both pretest, and posttest and retention test data were available in algebra. College policy allowed remedial students over a year's time to enroll in subsequent developmental courses and developmental students over two year's time to fulfill the College Algebra requirement, thus retention (pretests) were administered anywhere from one semester to a year and a half later.

5. To determine if students completing remedial/developmental courses demonstrated similar achievement when compared to non-remedial/non-developmental students in the same course, data was analyzed as follows:

a) Algebra posttest scores achieved by former remedial students were compared to algebra posttest scores achieved by students in the same developmental course (IM) who had been determined as not requiring a remedial course based on the placement criteria and pretest results.

b) Final grades in College Algebra achieved by former remedial/developmental students were compared to final grades achieved by non-remedial/non-development students in the same course in terms of the percent of students in each category successfully complete the course. The College Algebra classes

were selected based on an enrollment of at least 10% former remedial/developmental students.

Statistical analysis of the data was carried out using Independent t-tests as no significant correlations were found between the scores being compared.

Results

The results are presented according to the specifically stated objectives of the study.

With respect to the first and second objective of the study, the findings showed that significant differences consistently existed between the pre-instructional skills assessment, as measured by pretest scores, and the post-instructional assessment, as measured by posttest scores, of students in the remedial and/or developmental courses, over the three year period 1981-1984. Table I shows the analysis of the data by skill area (computation and/or algebra), course (Basic Computational Math, remedial, Intro to Computational Math and Intro to Math, developmental), semester (Fall or Spring) and by Academic Year (1981-82, 82-83, 83-84). Independent t-test analysis showed significant differences between pretest scores and posttest scores at .01 level in favor of the posttest scores in each skill area, for each course, for each semester and each academic year. The results are clearly consistent over the three year period. Independent t-test analysis was used as there was no significant correlation between pretest scores and posttest scores.

Table 1

COMPARISON OF PRETEST SCORES TO POSTTEST SCORES BY SKILL AREA, COURSE, SEMESTER AND ACADEMIC YEAR

Measure		Academic Year 81 - 82							Academic Year 82 - 83							Academic Year 83 - 84						
		Pretest			Posttest				Pretest			Posttest				Pretest			Posttest			
		N	Mean	SD	N	Mean	SD	t	N	Mean	SD	N	Mean	SD	t	N	Mean	SD	N	Mean	SD	t
M omputation	F	19	11.737	4.053	19	26.000	3.712	11.01*								29	11.896	3.976	29	24.897	5.185	10.53
	S	17	9.294	3.721	17	24.647	5.711	9.60*	26	10.423	3.657	26	23.807	3.805	12.68	55	11.564	4.391	55	23.945	4.636	14.25
M omputation	F	3	19.909	5.648	33	28.909	1.085	8.85*								73	18.247	4.600	73	24.863	3.043	10.18
	S															61	20.213	4.298	61	27.180	2.217	11.16
gebra	F	33	8.818	4.996	33	27.33	2.273	19.08*								73	8.78	5.045	73	20.904	6.283	12.77
	S															61	8.77	5.028	61	24.984	4.189	19.19
M omputation	F	33	21.242	2.5	33	27.363	2.234	10.33*	41	20.195	5.119	41	26.341	3.366	6.34	57	21.842	5.628	57	26.807	2.722	5.94
	S	57	21.386	3.390	57	26.158	4.309	6.51*	23	21.087	3.67	23	26.348	2.328	5.68	80	23.163	3.559	80	26.975	2.074	8.23
lgebra	F	33	12.727	6.156	33	26.09	3.156	10.93*	41	9.195	5.095	41	25.097	4.721	14.48	57	11.772	5.772	57	26.018	3.563	15.72
	S	57	10.912	6.057	57	25.719	4.411	14.79*	23	8.217	3.044	23	24.130	4.455	13.83	80	12.5	5.484	80	24.937	4.004	16.28

All t values significant at the .01 level

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Further , Table 2 shows the number and percent of students successfully completing the remedial and/or developmental courses for the entire 1981-1984 population. The success of the program is further supported by this data.

Table 2

SUCCESSFUL COMPLETION OF REMEDIAL AND DEVELOPMENTAL COURSE ANALYSIS FOR ENTIRE 1981-84 POPULATION

Course	Number Officially Enrolled	Passed		Failed *		Withdrawals	
		#	%	#	%	#	%
BCM	324	234	72.2%	73	22.8%	17	5%
ICM	727	533	73.3%	161	22.2%	33	4.5%
IM	763	566	74.2%	153	20%	44	5.8%

* F grades were awarded to students who:

a) appeared on official enrollment roster but never attended class
b) did not pass the posttest
c) passed the posttests (24/30 correct) but did not adequately satisfy the course requirements.

Looking at the entire remedial/developmental population for the three year period 1981-1984, over 72% of the 324 students officially enrolled in the remedial course (BCM) successfully completed it. Over 73% of 1,490 students officially enrolled in the developmental courses (ICM and IM) successfully completed it. It should be noted that according to college policy, F grades were awarded to students whose names appeared on the official roster and who never

attended class. Approximately 7% of the F grades were awarded to students who never attended class but appeared on the official grade roster. In addition, F grades were awarded to students who may have passed the posttest with a score of 24 out of 30 correct but who had not adequately satisfied the other course requirements. Approximately 9% of the F grades were awarded to students who passed the posttest but failed the course. The remaining F grades were awarded to students who did not pass the posttest with a score of 24 out of 30 correct.

For the third objective of the study, using the procedures and assumptions outlined in the Methods section, the findings indicated that the remedial/developmental program contributed significantly to the improvement of student mathematical skills.

Analysis of the data for 164 students who first enrolled at the college in Fall 1983, grouped according to those who enrolled in remedial/developmental courses in their first semester, Fall '83, and those who waited until their second semester, Spring '84, to enroll in remedial and/or developmental courses showed no significant differences between first semester and second semester placement scores, pretest scores or posttest scores. Table 3A shows the analysis of this data by course and skill area. Independent t-test analysis showed no significant differences between the two groups on the measures used, placement scores, pretest scores or posttest scores.

Table 3A

COMPARISON OF PLACEMENT SCORES, PRETEST SCORES AND POSTTEST SCORES FOR FIRST SEMESTER AND SECOND SEMESTER STUDENTS BY COURSE

Measure		1st Semester Mean	1st Semester SD	1st Semester N	2nd Semester Mean	2nd Semester SD	2nd Semester N	t
Placement Scores								
CM	Computation	11.385	4.102	18	11.276	4.208	28	.085
CM	Computation	17.923	2.784	15	18.742	4.285	37	.671
	Algebra	10.584	5.479	15	9.04	5.01	37	.959
M	Computation	21.756	4.054	28	22.104	2.753	38	.409
	Algebra	11.968	5.680	28	12.017	5.566	38	.035
Pretest Scores								
CM	Computation	11.5	3.650	18	11.607	4.524	28	.08
CM	Computation	18.86	2.503	15	19.567	4.324	37	.589
	Algebra	11.66	6.032	15	9.756	4.929	37	.750
M	Computation	22.607	3.947	28	23.342	2.24	38	.949
	Algebra	12.886	5.727	28	13.021	5.086	38	.103
Posttest Scores								
CM	Computation	23.83	5.953	18	23.643	4.739	28	.150
CM	Computation	23.8	4.057	15	24.0	2.248	37	.222
	Algebra	23.3	6.298	15	24.972	4.133	37	1.103
M	Computation	26.786	2.20	28	26.789	1.742	38	.006
	Algebra	26.5	2.285	28	25.342	2.714	38	1.802

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When first semester pretest scores were compared to first semester posttest scores, using independent t-test analysis, significant differences at the .01 level were found in favor of the posttest scores. Independent t-test analysis also showed significant difference at the .01 level in favor of the posttest scores when second semester pretest scores were compared to first semester posttest scores. The t values, for these pretest-posttest comparisons were comparable. Table 3B shows the analysis of this data by course and skill area.

Table 3B

COMPARISON OF FIRST SEMESTER PRETEST SC[illegible]O POSTTEST SCORES
AND FIRST SEMESTER POSTTEST SCORES TO SE[illegible]ESTER PRETEST SCORES

		First Semester Pretest Scores			First Semester Posttest Scores			
Measure		Mean	SD	N	Mean	SD	N	t
BCM	Computation	11.5	3.650	18	23.83	5.953	18	7.429*
ICM	Computation	18.86	2.503	15	23.8	4.057	15	4.04 *
	Algebra	11.66	6.032	15	23.3	6.298	15	5.01 *
CM	Computation	22.607	3.947	28	26.786	2.20	28	4.805 *
	Algebra	12.886	5.727	28	26.5	2.285	28	11.475 *

		Second Semester Pretest Scores			First Semester Posttest Scores			
Measure		Mean	SD	N	Mean	SD	N	t
BCM	Computation	22.607	4.524	28	23.83	5.953	18	7.712 *
ICM	Computation	19.567	4.324	37	23.8	4.057	15	3.192 *
	Algebra	9.756	4.929	37	23.3	6.298	15	8.095 *
CM	Computation	23.342	2.245	38	26.786	2.20	28	6.117 *
	Algebra	13.021	5.086	38	26.5	2.285	28	12.885 *

* Significant at the .01 level

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As there were no significant differences in placement scores between the two groups, the first semester group and second semester group, the two groups were judged comparable in terms of their initial mathematical skill abilities. If factors other than the program's activities contributed significantly to improved student mathematical skills as measured by pretest scores and posttest scores then there should have been significant differences in favor of the second semester group when pretest and posttest scores were compared for the two groups. Further, the differences between first semester posttest scores and second semester pretest scores should not have been as significant as the differences between first semester pretest scores and posttest scores. The results, however, as previously indicated, showed no significant differences between the first semester group and the second semester group. Therefore, it was judged that the program contributed significantly to the improvement of student mathematical skills.

With respect to the fourth objective of the study, the findings showed that students did retain a great deal of the content learned. There were significant differences in initial pretest scores in computation and algebra and respective retention test scores achieved at least one semester later. Independent t-test analysis showed significant differences at .01 level in favor of the retention test scores. Table 4A shows the analysis of this data.

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Table 4A

COMPARISON OF INITIAL PRETEST SCORES TO RETENTION TEST SCORES

Measure	Pretest Mean	Pretest SD	Pretest N	Retention Test Mean	Retention Test SD	Retention Test N	t
Computation	11.458	3.565	85	22.021	4.883	85	16.01
Algebra	10.091	5.021	115	21.252	5.698	115	11.75

* Significant at the .01 level

When posttest scores in computation and algebra were compared to respective retention test scores, signficant differences at the .01 level were found in favor of the posttest scores. Table 4B shows the analysis of this data.

Table 4B

COMPARISON OF POSTTEST SCORES AND RETENTION TEST SCORES

Measure	Posttest Mean	Posttest SD	Posttest N	Retention Test Mean	Retention Test SD	Retention Test N	t
Computation	25.152	4.363	85	22.021	4.883	85	.40 *
Algebra	26.686	2.925	115	21.251	5.698	115	.37 *

* Significant at the .01 level

Although the differences were statistically significant, the difference in posttest and retention test means in computation (25.152 vs. 22.021) and algebra (26.286 vs. 21.251) had no practical significance. Further, when the retention test scores, which were the subsequent course (IM) pretest scores, for former remedial students were compared to the pretest scores of students placed directly into the developmental course (IM) no significant differences were found using independent t-test analysis. Similarly when the retention test scores, the pretest scores for the College Algebra course, of former developmental students were compared to the pretest scores of non-remedial/development students, no significant differences were found using independent t-test analysis. Table 4C shows the comparison of pretest scores for the aforementioned groups.

Table 4C

COMPARISON OF PRETEST SCORES BETWEEN FORMER REMEDIAL AND/OR DEVELOPMENTAL STUDENTS AND NON REMEDIAL AND/OR DEVELOPMENTAL STUDENTS

	Former Remedial or Developmental Students			Non-remedial Non-developmental students			
Pretest	Mean	SD	N	Mean	SD	N	t
Computation	22.021	4.883	85	21.051	4.781	176	1.521
Algebra	21.252	5.698	115	20.66	6.134	108	.745

For objective five, the findings showed that former remedial students did significantly better on the algebra posttest than did students placed directly into the developmental courses (IM or ICM). A comparison of algebra posttest scores between former remedial students and students placed directly into the developmental course indicate significant differences at the .01 level in favor of the scores achieved by former remedial students. The results of this analysis are presented in Table 5A.

Table 5A

COMPARISON OF POSTTEST SCORES IN ALGEBRA BETWEEN FORMER REMEDIAL STUDENTS AND NON-REMEDIAL STUDENTS

Posttest	Former Remedial Mean	SD	N	Non-Remedial Mean	SD	N	t
Algebra	26.281	2.92	115	489	23.92	6.04	4.08 *

* Significant at the .01 level

Analysis of final grades achieved in College Algebra courses showed that 81% of the former remedial/developmental students successfully completed the college level mathematics course as compared to 80% of the non-remedial/developmental students. Table 5B shows the final grade analysis and grade.

Table 5B

FINAL GRADE ANALYSIS IN COLLEGE ALGEBRA COURSES FOR FORMER REMEDIAL/DEVELOPMENTAL STUDENTS AND NON-REMEDIAL/NON-DEVELOPMENTAL STUDENTS

	N	Passing		Percent receiving grade of				Failing		Withdrawal	
		#	%	A	B	C	D	#	%	#	%
Former Remedial/ Developmental Students	75	61	81%	7%	27%	36%	11%	7	9%	7	9%
Non-remedial Non-develop-mental students	130	104	80%	20%	30%	21%	9%	10	8%	16	12%

Summary and Conclusions

The purpose of the study was to assess the effectiveness of the remedial/developmental mathematics program developed and implemented at Ramapo College of New Jersey. The results of the study show the program to be highly effective and highly successful in achieving the goals of mathematics remediation. Not only do the mathematical skill abilities of students enrolled in the program significantly improve as a result of the program's activities, but more importantly students successfully completing the program appear to have the same

opportunity for success in subsequent mathematics courses as do students not requiring remediation.

The results of this study have national implications for remedial/developmental mathematics instruction on the post-secondary level. In general, it provides concrete evidence that remediation can achieve its objectives and that programs can be developed which significantly improve the mathematical skills performance of remedial/developmental students. In addition, given the statistically validated high degree of success of the Ramapo program, it can serve as a guide for other institutions of higher education which have not achieved the same degree of success. Successful mathematics remediation is not a luxury but a necessity since it increases the pool of potential students who opt for more mathematically or technically related fields, thereby filling a major demand in our society.